



[Sports Physical Therapy]

A Randomized Controlled Single-Blinded Comparison of Stretching Versus Stretching and Joint Mobilization for Posterior Shoulder Tightness Measured by Internal Rotation Motion Loss

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Background: Posterior shoulder tightness, as demonstrated by limited internal rotation range of motion, is a suggested factor in many shoulder pathologies. Methods to increase posterior shoulder mobility may be beneficial.

Hypothesis: Shoulder internal rotation range of motion will not change with either of 2 interventions: cross-body stretch alone and cross-body stretch plus posterior capsule joint mobilization.

Study Design: Randomized controlled single-blinded clinical trial.

Methods: The study comprised 39 college-age asymptomatic participants (7 men, 32 women) who were randomly assigned to 1 of 2 groups: stretching only (n, 20) and stretching plus posterior joint mobilizations (n, 19). All had a between-shoulder difference of internal rotation of 10° or more. Shoulder internal and external rotation was measured before and after a 4-week intervention period and 4 weeks postintervention. Participants in the stretching-only group performed the cross-body stretch on the limited side. Those in the other group (cross-body stretch plus joint mobilization) were treated with posterior joint mobilization techniques on the limited side.

Results: Overall means for internal rotation of the treated shoulders significantly increased over baseline at the end of the intervention period and at 4 weeks postintervention. External rotation in all shoulders remained unchanged. By the end of intervention, total motion increased significantly from baseline but decreased significantly from the end of intervention to 4 weeks postintervention. Although not statistically significant, the second group (cross-body stretch plus joint mobilization) had greater increases in internal rotation. At 4 weeks postintervention, the second group had maintained its internal rotation gains to a greater degree than those of the stretching-only group.

Conclusion: Internal rotation increased in both groups. Inclusion of joint mobilization in a rehabilitation program created trends toward increased shoulder internal rotation mobility.

Clinical Relevance: Both methods—cross-body stretch and cross-body stretch plus joint mobilization—may be beneficial for those with limited internal rotation range of motion.

Keywords: randomized controlled trial; shoulder; stretching; joint mobilization

Tightness of the posterior shoulder may be a common factor in many shoulder conditions, including impingement syndrome, rotator cuff tears, and labral

lesions.^{4,10,20,21,31,32,36-38} Posterior shoulder tightness may cause alterations in shoulder motion or muscle flexibility that are thought to increase risk of injury in athletes.¹⁹

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Posterior capsule tightness has been shown to create abnormal shoulder biomechanics. In a cadaveric study Harryman et al,¹¹ demonstrated that selective tightening of the posterior portion of the shoulder capsule causes a subsequent obligate anterior and superior translation of the humeral head during passive shoulder flexion. This occurs as a departure from classic descriptions of shoulder joint arthrokinematics. This abnormal motion could theoretically cause soft tissue impingement in the subacromial space in those who require overhead activities in either sport or vocation.

Further support for posterior shoulder tightness as a component of several pathologies comes from Myers et al²⁸ and Warner et al,³⁴ who found decreased internal rotation range of motion in patients with shoulder impingement syndrome and athletes with internal impingement symptoms. From these studies, it appears that increased shoulder internal rotation may be beneficial for both sporting and vocational activities.

Stretching and joint mobilization techniques are commonly used to treat internal rotation range of motion loss due to muscular or capsular limitations. Recent articles and studies recommend posterior shoulder stretching for those with losses of internal rotation.^{1,5,19,23,28} Techniques for stretching the posterior shoulder include the towel stretch,^{2,24} sleeper stretch,^{1,5,35} and the cross-body stretch.^{2,23} Despite the fact that authors recommend prophylactic stretching for the posterior shoulder, only 1 study has compared stretching techniques. McClure et al²³ found that the cross-body stretch in individuals with limited shoulder internal rotation was more effective than the sleeper stretch. Therefore, this technique was chosen to stretch the posterior shoulder in this study.

Clinicians use joint mobilization techniques as an intervention to increase soft tissue and capsular joint mobility.^{6,9,18,25,29} Proponents for joint mobilization techniques believe that by gliding the joint according to the convex-concave rule, patients can gain mobility.^{7,8,12,17,22,26} According to this rule, when a convex surface (humeral head) moves on a fixed concave surface (glenoid fossa), rolling and gliding movements of the joint surfaces occur in opposite directions.¹⁷ With this technique, a joint mobilization force or glide in a dorsal direction addresses hypomobility of the posterior shoulder.

Joint mobilization techniques for the shoulder have been assessed in cadaveric studies¹³⁻¹⁵ and in patients with adhesive capsulitis.^{16,29,33} No studies were found that included or compared posterior capsule joint mobilization techniques to stretching.

In a systematic review, Michlovitz et al²⁷ reported moderate support for joint mobilization use in patients whose loss of motion can be attributed to joint stiffness. The purpose of the present study was to assess passive shoulder internal rotation following 2 interventions: cross-body stretch alone and cross-body stretch plus joint mobilization.

Table 1. Participant characteristics.

	Stretching Only (n, 20)	Stretching + Mobilization (n, 19)
Men, women	4, 16	3, 16
Height, cm	168.3 ± 10.1	169.2 ± 12.2
Body mass, kg	67.5 ± 11.4	61.4 ± 11.0

Table 2. Intraclass and interclass correlation coefficients.

Measurement	Intraclass		Interclass	SEM ^a	MDC ^b
	Rater 1	Rater 2			
Internal rotation at 90° abduction					
Dominant	.83	.88	.84	4.16	11.36
Nondominant	.95	.95	.94	2.35	9.62
External rotation at 90° abduction					
Dominant	.94	.92	.94	2.75	7.25
Nondominant	.97	.89	.94	2.75	7.24

^aStandard error of the measurement (in degrees); calculated for interrater reliability.

^bMinimal detectable change (in degrees) was calculated as standard error of the measurement × 1.96√2.

METHODS

A prospective randomized repeated-measures design compared 2 techniques to increase internal rotation range of motion in healthy college-age participants with a unilateral difference. A random assignment placed participants into 1 of 2 interventions: cross-body stretch alone or cross-body stretch plus posterior joint mobilizations. A control group was not used. The interventions were compared to each other, and treated shoulders were compared to the untreated shoulders.

PATIENTS

Forty-six individuals were measured to identify those with a 10° or greater asymmetry in shoulder internal rotation measured at 90° of abduction. The 39 who met the asymmetry criteria thus formed a convenience sample and were randomly assigned to 1 of 2 intervention groups (Table 1): 20 performed the cross-body stretch only whereas 19 performed the cross-body stretch and received posterior shoulder joint mobilizations. Exclusion criteria included a history of shoulder surgery, shoulder symptoms requiring medical treatment in the last year, or shoulder pain at the time of study. All subjects read and signed an informed consent approved by the university's institutional review board.



Figure 1. External rotation measurement procedure.



Figure 2. Finding internal rotation end range of motion.

MEASUREMENT PROCEDURE

Reliability

Intratester and intertester reliability were established on a pilot group of 30 asymptomatic patients (60 shoulders). Both examiners were fellowship-trained sports medicine physicians. Measurements occurred 30 to 60 minutes apart. Separate reliability coefficients were calculated for shoulder internal and external rotation for each tester on each side (ICC 3, 2). Intraclass correlation (ICC 2, 2) was calculated for intertester reliability (Table 2).

The primary measurements were passive shoulder internal and external rotation with the humerus abducted to 90° in the frontal plane with the patient lying supine on a standard examination table. The same examiner performed the pretest and the posttest measurements on the same participants. Throughout the study, each examiner was blinded to participant groupings to reduce the risk of measurement bias.

Range of Motion Measurement

For measurement of external rotation, the participant lay supine with the shoulder abducted in 90° and the elbow flexed 90°. A towel was placed posterior to the humerus to ensure a neutral horizontal position. The forearm was placed vertical (perpendicular to the support surface) while the examiner passively externally rotated the humerus with 1 hand at the subject's wrist. The scapula was stabilized with the other hand. End range of glenohumeral external rotation was identified when resistance to any further motion was encountered and attempts to overcome the resistance caused a posterior tilt or retraction of the scapula (Figure 1).³⁰ Measurements were made with the arm at end range, with the inclinometer on the ventral forearm surface. No additional pressure was applied to the shoulder during the measurement process.

For internal rotation, the participant lay supine, as described previously, with the shoulder abducted 90° and the elbow flexed 90°. The inclinometer was placed on the dorsal surface of the forearm. The forearm was vertical to start while the glenohumeral joint was then passively internally rotated. The scapula was stabilized while the examiner monitored compensatory movement at the end of internal rotation (Figure 2). When the scapula started to protract, the measurement was taken to differentiate glenohumeral internal rotation from composite shoulder internal rotation (Figure 3). Passive measurements removed the possibility of muscle insufficiency as a cause of motion difference.

INTERVENTION

One group performed the cross-body stretch alone by passively pulling the humerus across the body into horizontal adduction with the opposite arm, without concern for scapular stabilization (Figure 4). Each patient performed 5 repetitions of the cross-body stretch, holding each for 30 seconds.

The second group performed the cross-body stretch as described for the first group, in addition they received joint mobilizations.

Joint mobilizations were performed by 2 physical therapists (specialty board certified, American Physical Therapy Association). Patients were treated with grade III and IV joint mobilizations^{7,8} directed toward the posterior capsule for a total of 10 minutes a minimum of 2 times per week over a 4-week period. Care was taken to ensure that the joint mobilization technique was done in a posterior lateral glide to achieve translation along the joint surface (Figure 5). Joint mobilizations occurred separate from stretches in all participants and at all times.

Both groups were instructed to perform the stretching exercises to a point of mild discomfort at least once daily for



Figure 3. Internal rotation measurement procedure.



Figure 4. Cross-body stretching procedure.

5 repetitions, holding each stretch for 30 seconds. A daily log sheet was issued to monitor compliance. Participants also received written instructions and pictures of the stretching techniques.

Range of motion measurements were taken at the initiation and completion of the study. Posttesting occurred at 4 weeks following completion of the study.

We decided a priori that participants would be required to complete at least 15 stretching sessions during the 4-week period for their data to be included in the analysis. This required the participant to stretch a minimum of 3 to 4 sessions per week. Shoulder mobilization 2 to 3 times per week was preferred (minimum, 2 times per week). Missed sessions owing to illness, vacation, and other considerations were allowed.

DATA ANALYSIS

Descriptive statistics were calculated for all variables, and all dependent variables were examined for normal distribution



Figure 5. Posterior glide joint mobilization procedure.

and homogeneity of variance assumptions. Total motion was calculated by separately adding internal and external rotation of the untreated and treated shoulders. A 2×3 analysis of variance was used to analyze differences between measurement means—specifically, with 1 between-subjects factor (type of intervention) and 1 within-subjects factor (degrees of motion at baseline, 4 weeks, and 4 weeks postintervention cessation). To evaluate differences over time between interventions (treated and untreated shoulders), a 2×6 analysis of variance was used. Alpha level for all analyses was set at .05. Appropriate post hoc comparisons used Bonferroni's correction factor. All data were analyzed using SPSS 15.5.

RESULTS

Height and weight between the intervention groups was not significantly different (see Table 1). Each patient recorded compliance for the duration of the interventions, which was similar for the 2 groups ($t = 0.93$; $P = .58$). The stretching-only group averaged 20.33 sessions (range, 12-28) whereas the stretching-plus-joint-mobilization group averaged 21.27 (range, 13-28). Each member of the latter group underwent 8 to 10 sessions of joint mobilization. No one was dismissed from the study owing to poor compliance.

The proportion of men:women was not significantly different between the 2 groups (4:16 to 3:16). Two participants had a loss of internal rotation on the nondominant shoulder.

Table 3 presents the mean range of motion for each intervention at each time. No significant interaction occurred between type of intervention and time. There was no significant main effect for type of intervention. A significant main effect was found for time. For the treated shoulders, both groups demonstrated significant increases in internal rotation from baseline to 4 and 8 weeks (Table 3 and Figure 6). In both groups, the increases in 4-week total rotation motion in the treated shoulders reflect a real increase in internal rotation because external rotation remained essentially unchanged. Pairwise comparisons using means for total motion for the

Table 3. Range of motion means \pm standard deviations at baseline (preintervention), at 4 weeks (intervention), and at 8 weeks (postintervention).^a

Measures	Preintervention (Baseline)	Intervention (at 4 Weeks)	Postintervention (at 8 Weeks)
Stretching only			
C IR	63.5 \pm 9.3	69.4 \pm 12.4	64.0 \pm 11.1
C ER	94.3 \pm 13.3	91.8 \pm 8.9	91.3 \pm 7.5
C Total	157.8 \pm 12.2	161.2 \pm 11.8	155.3 \pm 10.9
T IR	44.4 \pm 10.1 ^{b,c}	59.8 \pm 11.7 ^b	56.2 \pm 10.0 ^c
T ER	105.3 \pm 12.8	103.8 \pm 10.1	100.3 \pm 10.2
T Total	149.7 \pm 11.4 ^b	163.6 \pm 11.9 ^b	156.45 \pm 13.1
Stretching + mobilization			
C IR	61.3 \pm 10.0	67.6 \pm 13.2	62.4 \pm 11.6
C ER	92.1 \pm 8.8	89.9 \pm 6.8	92.5 \pm 9.4
C Total	153.4 \pm 12.5	157.5 \pm 13.2	154.9 \pm 13.6
T IR	44.1 \pm 10.1 ^{b,c}	63.1 \pm 12.7 ^b	55.2 \pm 9.5 ^{b,c}
T ER	100.2 \pm 8.9	98.2 \pm 9.1	96.7 \pm 10.6
T Total	144.3 \pm 10.4 ^b	161.3 \pm 15.1 ^b	151.9 \pm 14.5

^aC, control; T, treated; IR, internal rotation; ER, external rotation.

^bSignificant increase ($P \leq .05$) between periods for noted measurement for each intervention group.

^cSignificant increase ($P \leq .05$) between periods for noted measurement for each intervention group.

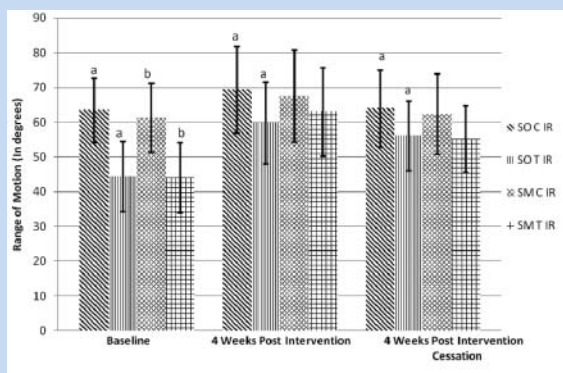


Figure 6. Range of motion means (\pm standard deviations) for internal rotation (IR) at baseline, at end of 4-week intervention, and at 4 weeks postintervention. SO C IR, stretching only, control shoulder; SO T IR, stretching only, treated shoulder; SM C IR, stretching + mobilization, control shoulder; SM T IR, stretching + mobilization, treated shoulder; a, in SO group, treated shoulder ROM significantly decreased from control; b, in SM group, treated shoulder ROM significantly decreased from control.

treated shoulder increased significantly from baseline to 4 weeks and remained increased, although not significantly, 4 weeks after the intervention.

Differences between the untreated and treated shoulders in each group at each time were separately analyzed using paired-samples *t* tests. At baseline, the treated shoulder had significantly less motion than that of the untreated shoulder.

At week 4, in the stretching-plus-mobilization group, internal rotation between the treated and untreated shoulders was no longer significantly different (4.5°). In addition, the 4-week internal rotation of the treated shoulder (63.1°) exceeded the baseline measurement for the untreated shoulder (61.3°). In the stretching-plus-mobilization group at 4 weeks postintervention, none of the measurements between the treated and untreated shoulders were significantly different (Table 3 and Figure 6). External rotation remained essentially unchanged at all times in all shoulders (Table 3 and Figure 7). Total motion in the untreated shoulders was not significantly different in either group except at baseline in the stretching-only group (Table 3 and Figure 8). Changes in internal rotation accounted for the changes in total motion in the treated shoulders.

DISCUSSION

Examination of the 2 interventions showed that stretching plus mobilization might be more effective in increasing internal rotation and maintaining that increase.

In both intervention groups, as shoulder internal rotation in the treated shoulder increased, shoulder external rotation decreased. It is likely that a gain of internal rotation resulted in a concomitant loss of external rotation. McClure et al²³ did not find any changes in external rotation. The amount of external rotation loss in this study was small, not statistically significant, and potentially not clinically significant as well. The internal rotation gained by both intervention groups probably accounts for most of the increase in total motion. The standard error of the measurement and, therefore, the minimal clinical difference for internal rotation of the treated shoulders were the largest of the 4 measurements

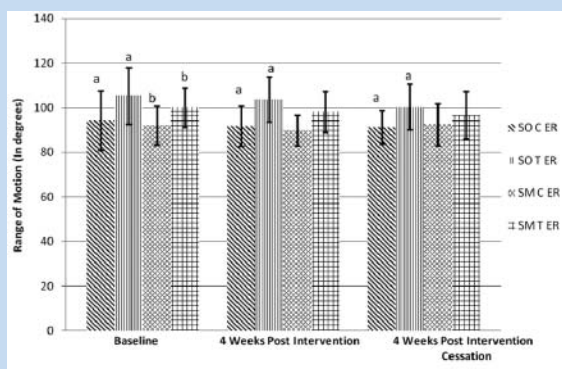


Figure 7. Range of motion means (\pm standard deviations) for external rotation (ER) at baseline, at end of 4-week intervention, and at 4 weeks postintervention. SO C ER, stretching only, control shoulder; SO T ER, stretching only, treated shoulder; SM C ER, stretching + mobilization, control shoulder; SM T ER, stretching + mobilization, treated shoulder; a, in SO group, control shoulder ROM significantly greater than treated shoulder; b, in SM group, control shoulder ROM significantly greater than treated shoulder.

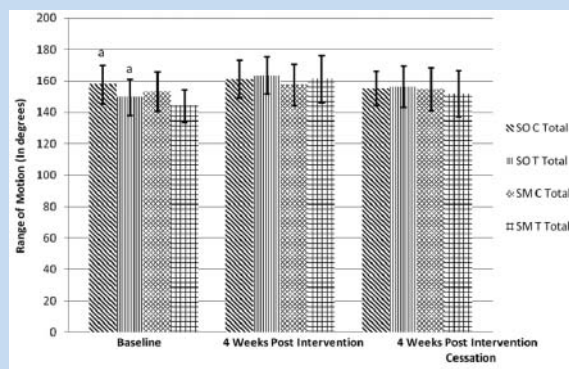


Figure 8. Range of motion means (\pm standard deviations) for total motion at baseline, at end of 4-week intervention, and at 4 weeks postintervention. SO C, stretching only, control shoulder; SO T, stretching only, treated shoulder; SM C, stretching + mobilization, control shoulder; SM T, stretching + mobilization, treated shoulder; a, in SO group, control shoulder ROM significantly greater than treated shoulder.

(Table 2). Because this was the most critical factor to finding significant interactions in this study, measurement error may have played a role. However, even with a minimal clinical difference of 11.4° , the significant internal rotation increases achieved and maintained in the stretching-plus-mobilization group are probably not the result of measurement error.

We note 4 limitations: asymptomatic participants, a convenience sample, measurement error, and a 10° difference in internal rotation between shoulders. We used asymptomatic patients with no known pathology, rather than overhead athletes or those with

shoulder symptoms and pathology who were seeking medical attention. We used this population to demonstrate the possible effectiveness of stretching plus mobilization in general, before its application to a more vulnerable population.

We performed a power analysis a priori. To obtain a power of at least .80 for a 2×3 analysis of variance, using a conservative effect size (.35) and correlation between raters (.40), required 35 participants per group.³ It was not possible to obtain this optimal number to meet a power of at least .80.

Because of the relatively large measurement error in internal rotation, a 10° discrepancy in shoulder ranges of motion may have been an insufficient requirement to allow for between-group differences. This amount of motion asymmetry was used in a similar study.²³ The baseline data showed that the mean difference between shoulders in the present study was actually 17° , requiring patients to increase their internal rotation by only 17° to become completely symmetrical with the untreated side. Greater rotation changes may occur in those with pathology. This proposed ceiling effect (ie, 10° to 17° limitation in the present study) is related to the difference between normal and pathological tissue and may have thus influenced the results.

Glenohumeral internal rotation deficit may be a predisposing factor for multiple injuries in overhead athletes.^{4,10,21,29,31,32,36-38}

Therefore, it is clinically important to prevent loss and/or increase internal rotation range of motion.^{10,19,21,31,32,36-38} Harryman et al¹¹ noted a superior and anterior translation of the humeral head during passive forward flexion in the presence of a simulated posterior capsule contracture in a cadaveric model. An unopposed superior translation will result in impingement. Owing to a posterior shoulder contracture, impingement syndrome may lead to partial rotator cuff tearing. Ticker et al³¹ reported thickened posterior capsules in patients diagnosed with limited internal rotation, in conjunction with subacromial impingement. Furthermore, Burkhart et al⁵ believed that athletes with glenohumeral internal rotation deficit exhibit a posterolateral shift increasing contact among the humeral head, labrum, and rotator cuff in the late cocking phase of the throwing shoulder. This may lead to labral peelback and cause a type II superior labrum anterior-to-posterior lesion. Heyworth and Williams¹³ also thought that stretching of the posterior shoulder structures may be a useful adjunct to treatment for pathologic internal impingement. Lengthening of the posterior shoulder structures via posterior shoulder joint mobilization techniques will allow the humeral head to glide in the appropriate direction, allowing normal glenohumeral arthrokinematics and decreasing the risk of these potentially pathological conditions. What has yet to be objectively determined is the amount of internal rotation motion needed to create symptom resolution, although Burkhart et al observed that symptomatic athletes usually have differences of motion loss greater than 25° between shoulders. Approximately 90% of athletes responded well to a progressive stretching program to bring this internal rotation loss to an acceptable level.⁵ Their recommended acceptable level is less than 20° or less than 10% of the total arc of movement seen in the nondominant shoulder. McClure et al²³ demonstrated that the cross-arm stretch was more effective than the sleeper stretch for the posterior shoulder. A

combination of the cross-arm stretch plus joint mobilization may be an even more effective method for treatment of posterior shoulder tightness.

CONCLUSION

The cross-arm stretch with joint mobilization and the cross-arm stretch alone can significantly increase shoulder internal rotation following 4 weeks of intervention in a group of asymptomatic college-age students.

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REFERENCES

- Bach HG, Goldberg BA. Posterior capsular contracture of the shoulder. *J Am Acad Orthop Surg*. 2006;14:265-267.
- Bandy WD, Sanders B. *Therapeutic Exercise: Techniques for Intervention*. Baltimore, MD: Lippincott Williams & Wilkins; 2001.
- Bausell RB, Li YF. *Power Analysis for Experimental Research*. Cambridge, UK: Cambridge University Press; 2002.
- Burkhart SS. Internal impingement of the shoulder. *Inst Course Lect*. 2006;55:29-34.
- Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology, part I: pathoanatomy and biomechanics. *Arthroscopy*. 2003;19:404-420.
- Conroy DE, Hayes KW. The effect of joint mobilization as a component of comprehensive treatment for primary shoulder impingement syndrome. *J Orthop Sports Phys Ther*. 1998;28:3-14.
- Cyriax J. *Textbook of Orthopedic Medicine: Diagnosis of Soft Tissue Lesions*. 6th ed. Vol 1. Baltimore, MD: Williams & Wilkins; 1975.
- Edmond SL. *Manipulation and Mobilization: Extremities and Spinal Techniques*. 2nd ed. St. Louis, MO: Mosby; 2006.
- Ekelund AL, Rydell N. Combination treatment for adhesive capsulitis of the shoulder. *Clin Orthop Relat Res*. 1992;282:105-109.
- Grossman MG, Tibone JE, McGarry MH, Schneider DJ, Veneziani S, Lee TQ. A cadaveric model of the throwing shoulder: a possible etiology of superior labrum anterior-to-posterior lesions. *J Bone Joint Surg Am*. 2005;87:824-831.
- Harryman DT II, Sidles JA, Clark JM, McQuade KJ, Gibb TD, Matsen FA III. Translation of the humeral head on the glenoid with passive glenohumeral motion. *J Bone Joint Surg Am*. 1990;72:1334-1343.
- Hertling D, Kessler RM. *Management of Common Musculoskeletal Disorders: Physical Therapy Principles and Methods*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins; 1996.
- Heyworth BE, Williams RJ. Internal impingement of the shoulder. *Am J Sports Medicine*. 2009;37:1024-1037.
- Hsu AT, Hedman T, Chang JH, et al. Changes in abduction and rotation range of motion in response to simulated dorsal and ventral translational mobilization of the glenohumeral joint. *Phys Ther*. 2002;82:544-556.
- Hsu AT, Ho L, Ho S, Hedman T. Joint position during anterior-posterior glide mobilization: Its effect on glenohumeral abduction range of motion. *Arch Phys Med Rehabil*. 2000;81:210-214.
- Johnson AJ, Godges JJ, Zimmerman GJ, Ounonian LL. The effect of anterior versus posterior glide joint mobilization on external rotation range of motion in patients with shoulder adhesive capsulitis. *J Orthop Sports Phys Ther*. 2007;37:88-99.
- Kaltenborn F. *Manual Mobilization of the Extremity Joints*. Oslo, Norway: Olaf Norlis Bokhandel; 1989.
- Kamkar A, Irrgang JJ, Whitney SL. Non-operative management of secondary shoulder impingement syndrome. *J Orthop Sports Phys Ther*. 1994;17:212-224.
- Kibler WB, Chandler TJ. Range of motion in junior tennis players participating in a injury risk modification program. *J Science Med Sport*. 2003;6:51-62.
- Lintner D, Mayhol M, Uzodinma O, Jones R, Labossiere D. Glenohumeral internal rotation deficits in professional pitchers enrolled in an internal rotation stretching program. *Am J Sports Med*. 2007;35:617-621.
- Ludewig PM, Cook TM. Translations of the humerus in persons with shoulder impingement symptoms. *J Orthop Sports Phys Ther*. 2002;32:248-259.
- Maitland GD. *Peripheral Manipulation*. Woburn, MA: Butterworth Inc; 1977.
- McClure P, Balaicuis J, Heiland D, Broersma ME, Thorndike CK, Wood A. A randomized controlled comparison of stretching procedures for posterior shoulder tightness. *J Orthop Sports Phys Ther*. 2007;37:108-114.
- McClure P, Bialker J, Neff N, Williams G, Karduna A. Shoulder function and 3-dimensional kinematics in people with shoulder impingement syndrome before and after a 6-week exercise program. *Phys Ther*. 2004;84:832-848.
- McClure P, Flower KR. Treatment of limited shoulder motion: a case study based on biomechanical considerations. *Phys Ther*. 1992;72:929-936.
- Mennell JM. *Joint Pain: Diagnosis and Treatment Using Manipulative Techniques*. Boston, MA: Little, Brown & Co; 1964.
- Michlovitz SL, Harris BA, Watkins MP. Therapy interventions for improving joint range of motion: a systematic review. *J Hand Ther*. 2004;17:118-131.
- Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Glenohumeral range of motion deficits and posterior shoulder tightness in throwers with pathologic internal impingement. *Am J Sports Med*. 2006;34:385-391.
- Nicholson G. The effects of joint passive joint motion on pain and hypomobility associated with adhesive capsulitis of the shoulder. *J Orthop Sports Phys Ther*. 1985;6:238-246.
- Norkin CC, White DJ. *Measurement of Joint Motion: A Guide to Goniometry*. 3rd ed. Philadelphia, PA: FA Davis Co; 2003.
- Ticker JB, Beim GM, Warner JJ. Recognition and treatment of refractory posterior capsular contracture of the shoulder. *Arthroscopy*. 2000;16:27-34.
- Tyler TF, Nicholas SJ, Roy T, Gleim GW. Quantification of posterior capsule tightness and motion loss in patients with shoulder impingement. *Am J Sports Med*. 2000;28:668-673.
- Vermeulen H, Obermann W, Burger B, Kok G, Rozing P. End-range mobilization techniques in adhesive capsulitis of the shoulder joint: a multiple-subject case report. *Phys Ther*. 2000;80:1204-1213.
- Warner JJ, Micheli LJ, Arslanian LE, Kennedy JH, Kennedy R. Patterns of flexibility, laxity, and strength in normal shoulders and shoulders with instability and impingement. *Am J Sports Med*. 1990;18:366-375.
- Weldon EJ III, Richardson AB. Upper extremity overuse injuries in swimming: a discussion of swimmer's shoulder. *Clin J Sport Med*. 2001;20:423-428.
- Wilk KE, Arrigo C. Current concepts in the rehabilitation of the athletic shoulder. *J Orthop Sports Phys Ther*. 1993;18:365-378.
- Wilk KE, Meister K, Andrews JR. Current concepts in the rehabilitation of the overhead throwing athlete. *Am J Sports Med*. 2002;30:136-151.
- Wilk KE, Reinold MM, Dugas JR, Arrigo CA, Moser MW, Andrews JR. Current concepts in the recognition and treatment of superior labral (SLAP) lesions. *J Orthop Sports Phys Ther*. 2005;35:273-291.

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